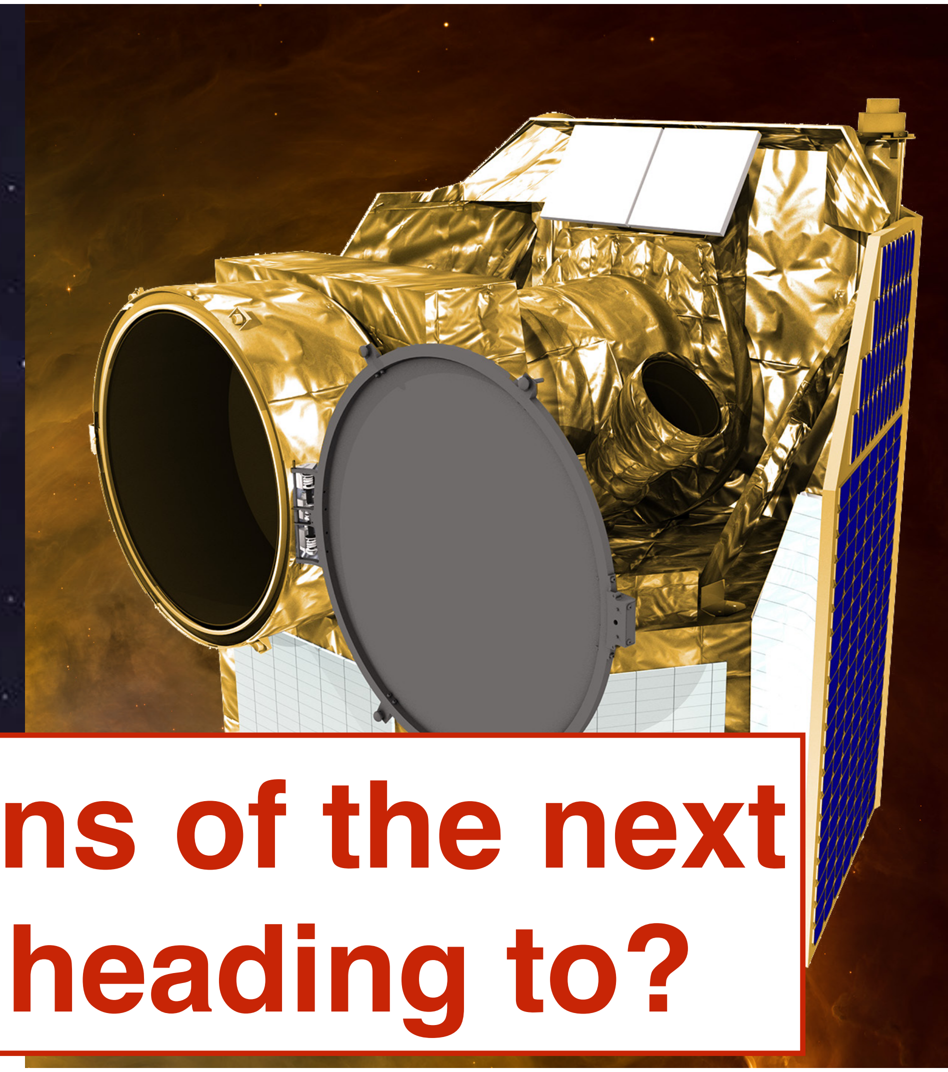
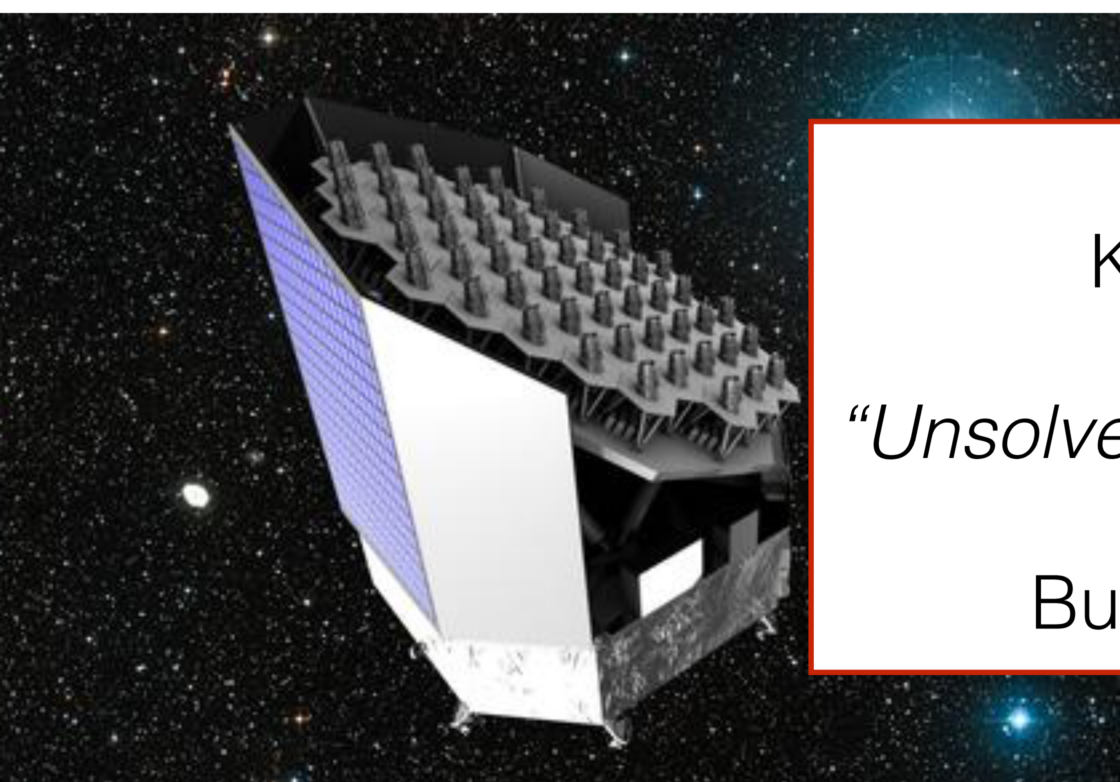
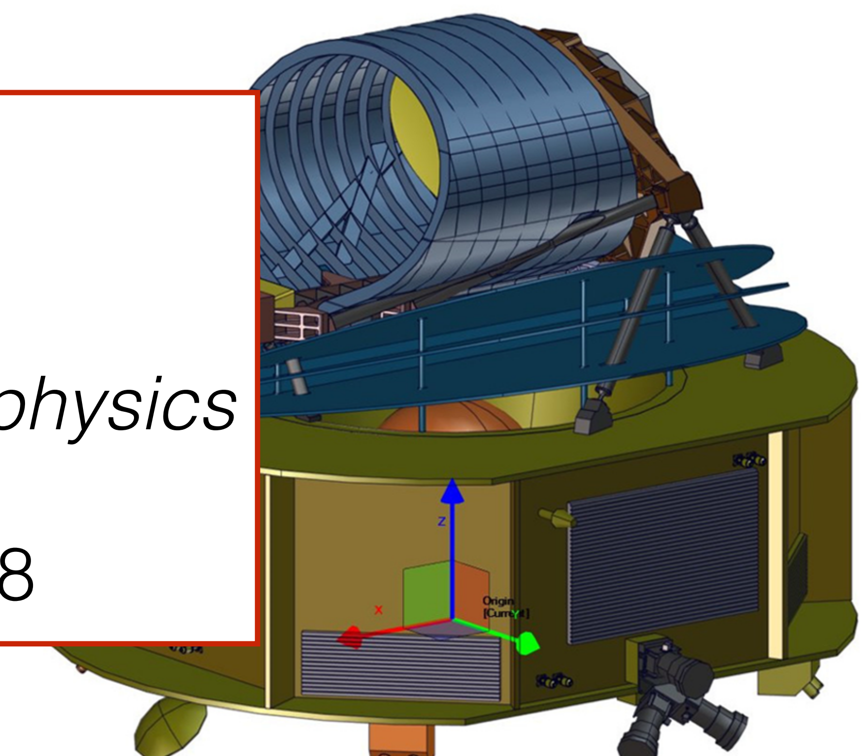


Exoplanet space missions of the next decade: where are we heading to?



László Kiss
Konkoly Observatory

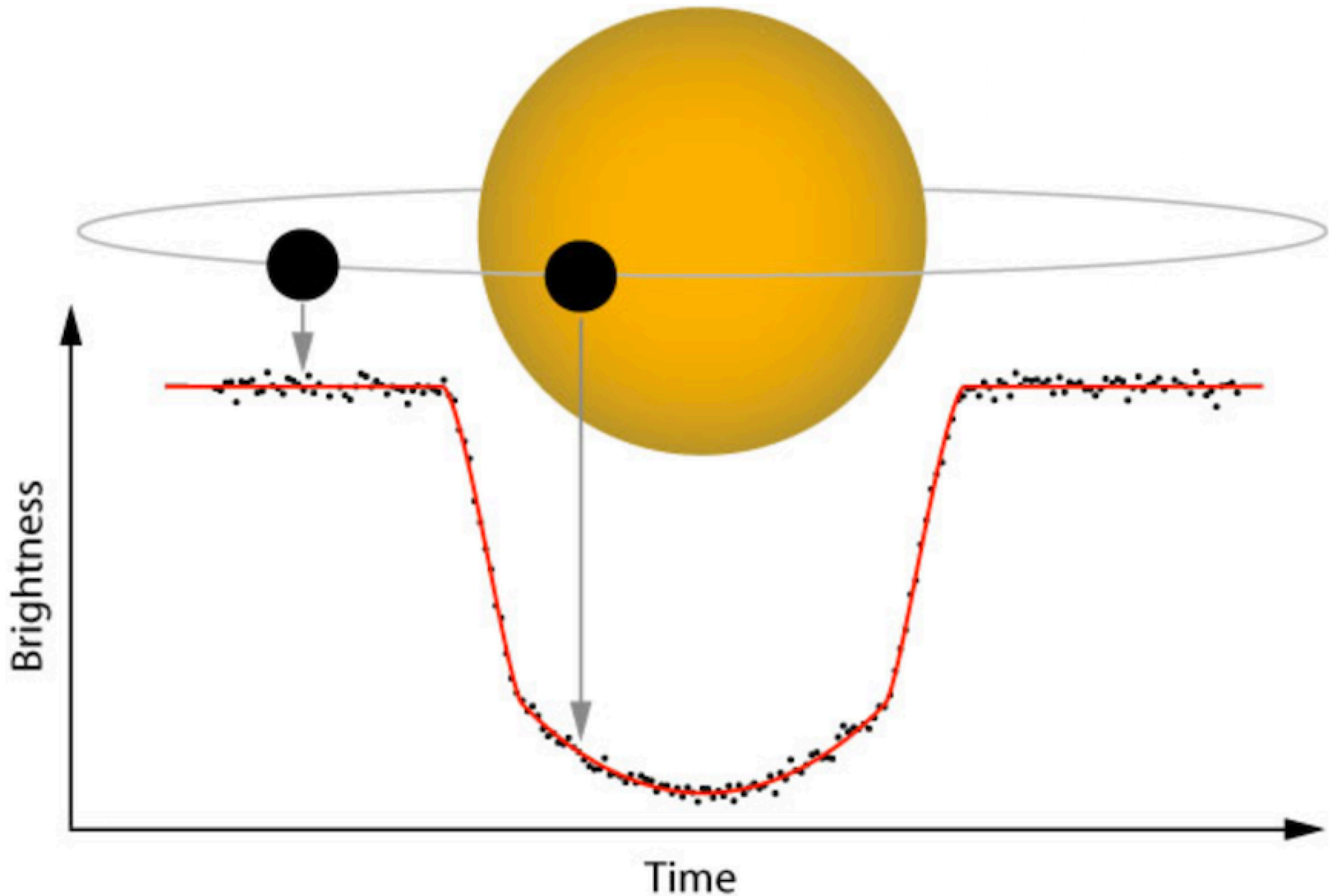
“Unsolved Problems in Astrophysics and Cosmology”
Budapest, July 2-6 2018



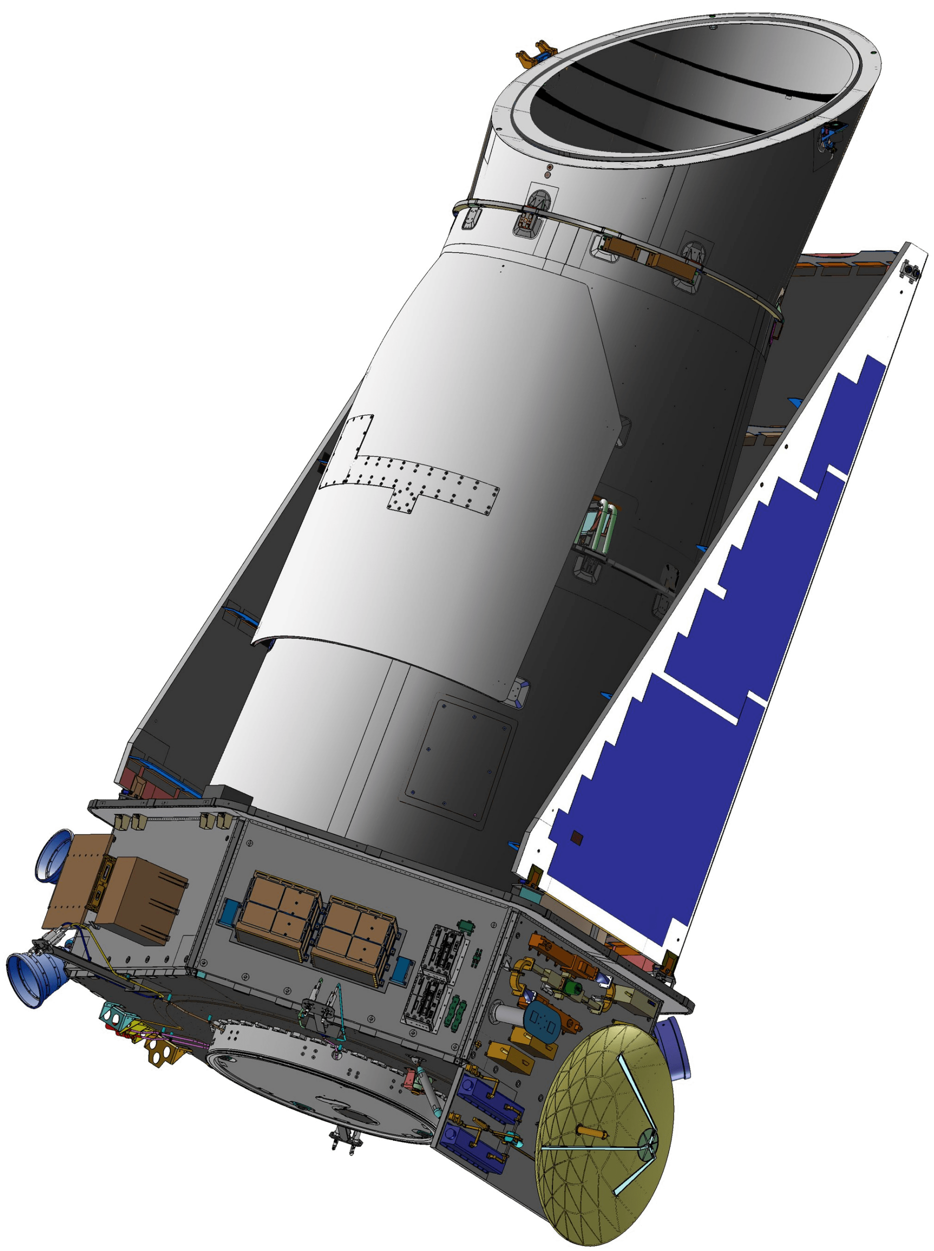
Is there life elsewhere?

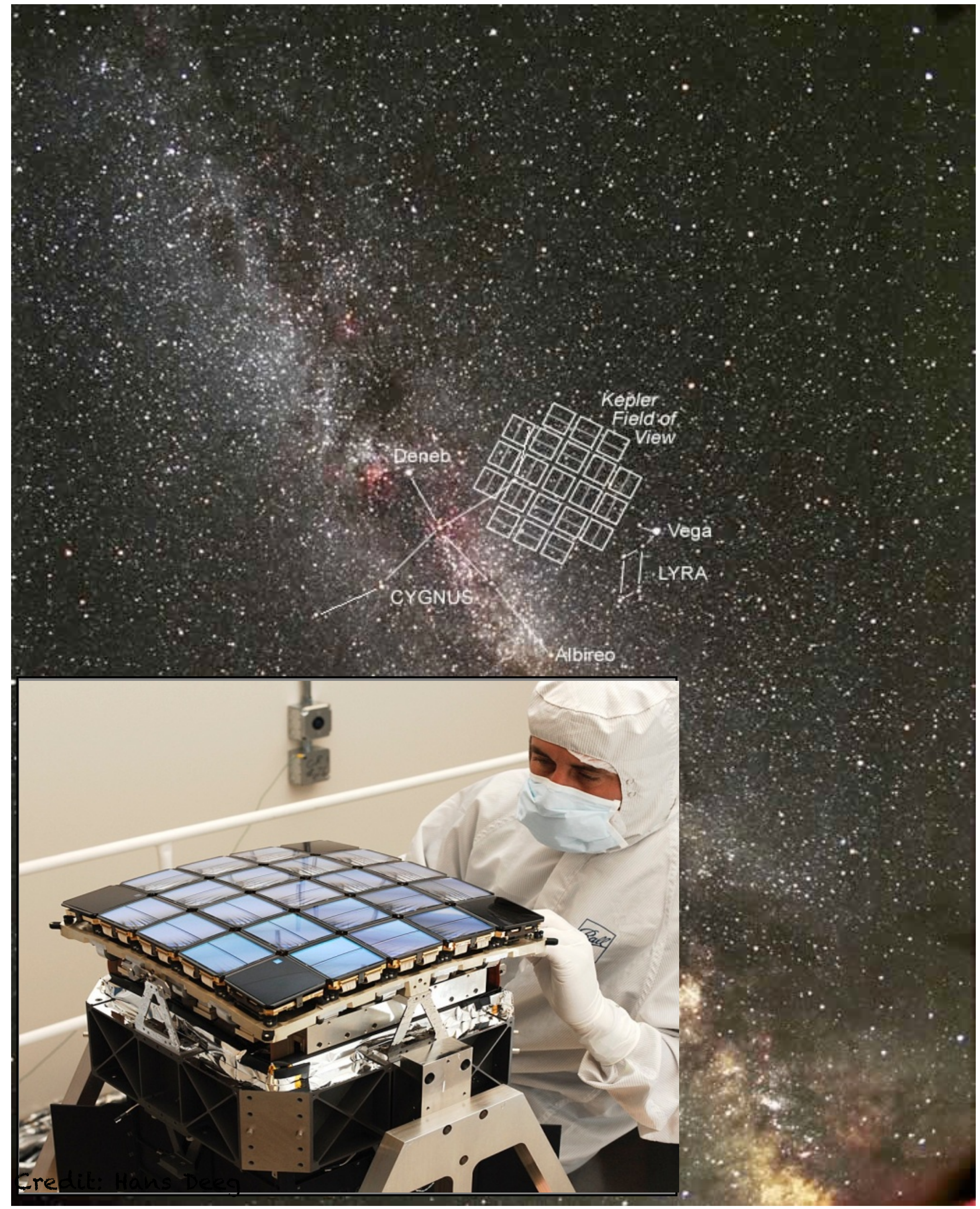
Are we alone?

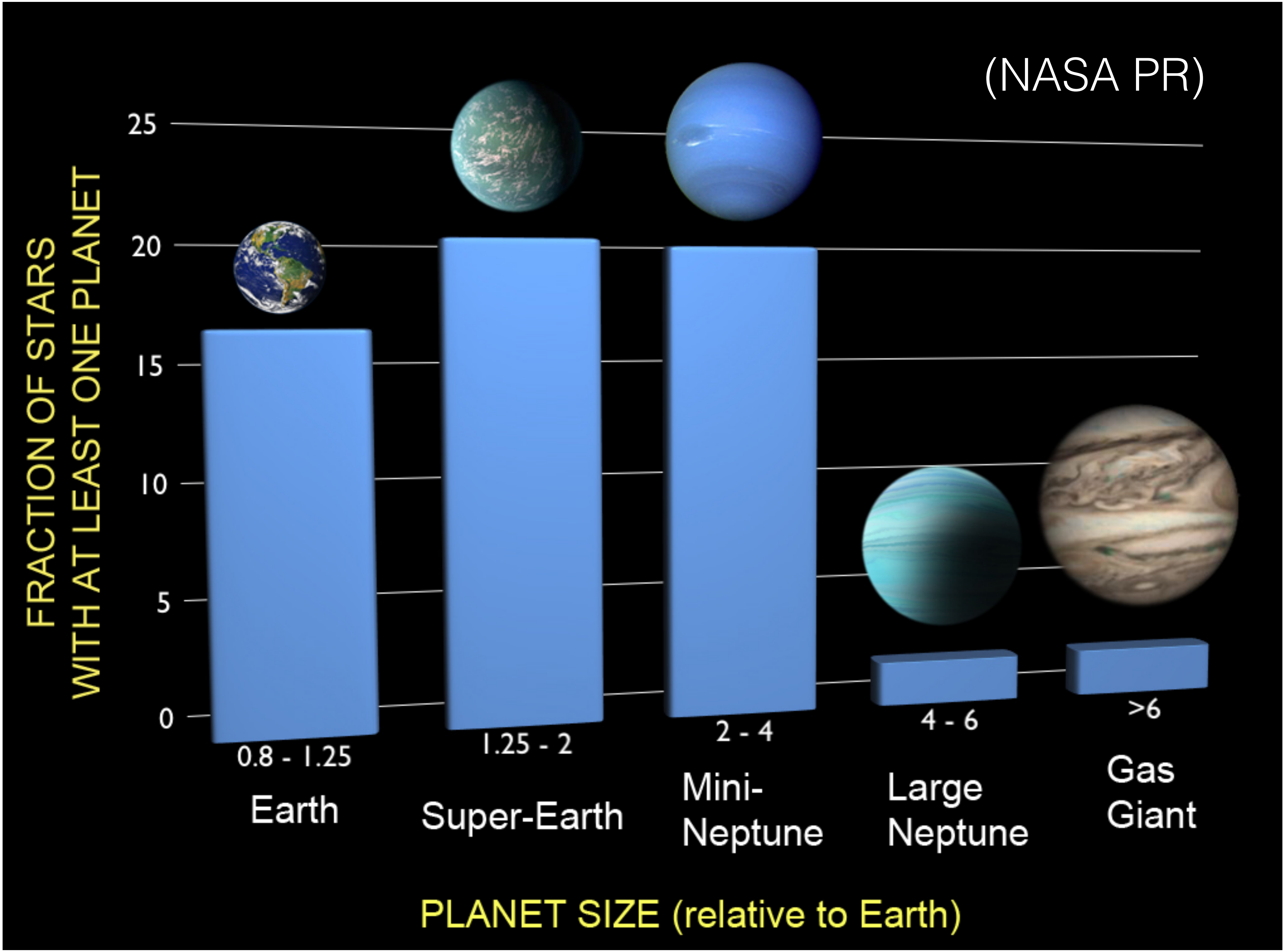
Transiting exoplanets: since 2000

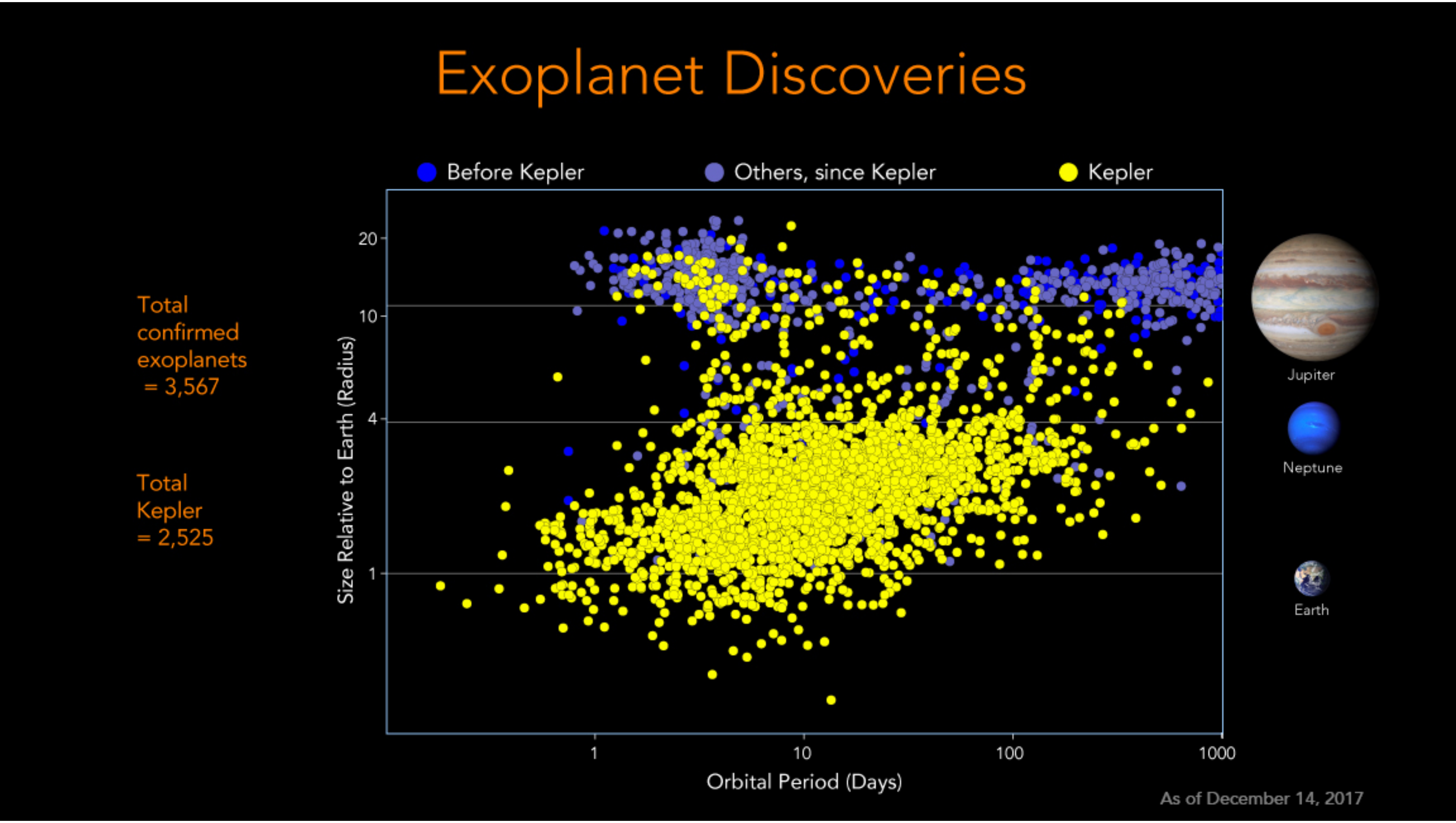


The Kepler era: since 2009





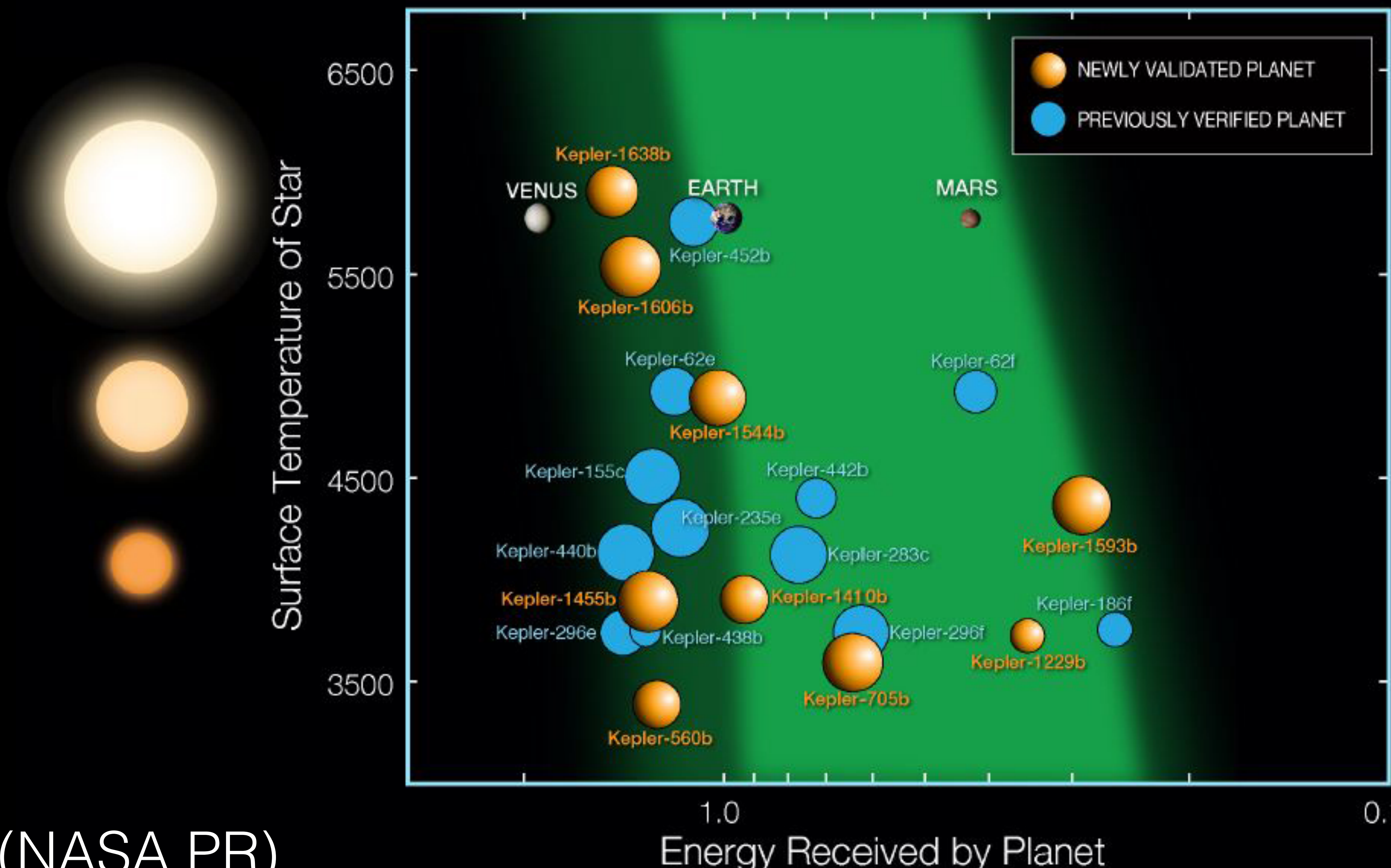

(NASA PR)
FRACTION OF STARS
WITH AT LEAST ONE PLANET
25
20
15
10
5
0
0.8 - 1.25
Earth
1.25 - 2
Super-Earth
2 - 4
Mini-
Neptune
4 - 6
Large
Neptune
>6
Gas
Giant
PLANET SIZE (relative to Earth)


Exoplanet Discoveries
Before Kepler
Others, since Kepler
Kepler
Total confirmed exoplanets = 3,567
Total Kepler = 2,525
Size Relative to Earth (Radius)
20
10
4
1
1
10
100
1000
Orbital Period (Days)
Jupiter
Neptune
Earth
As of December 14, 2017

(NASA PR)

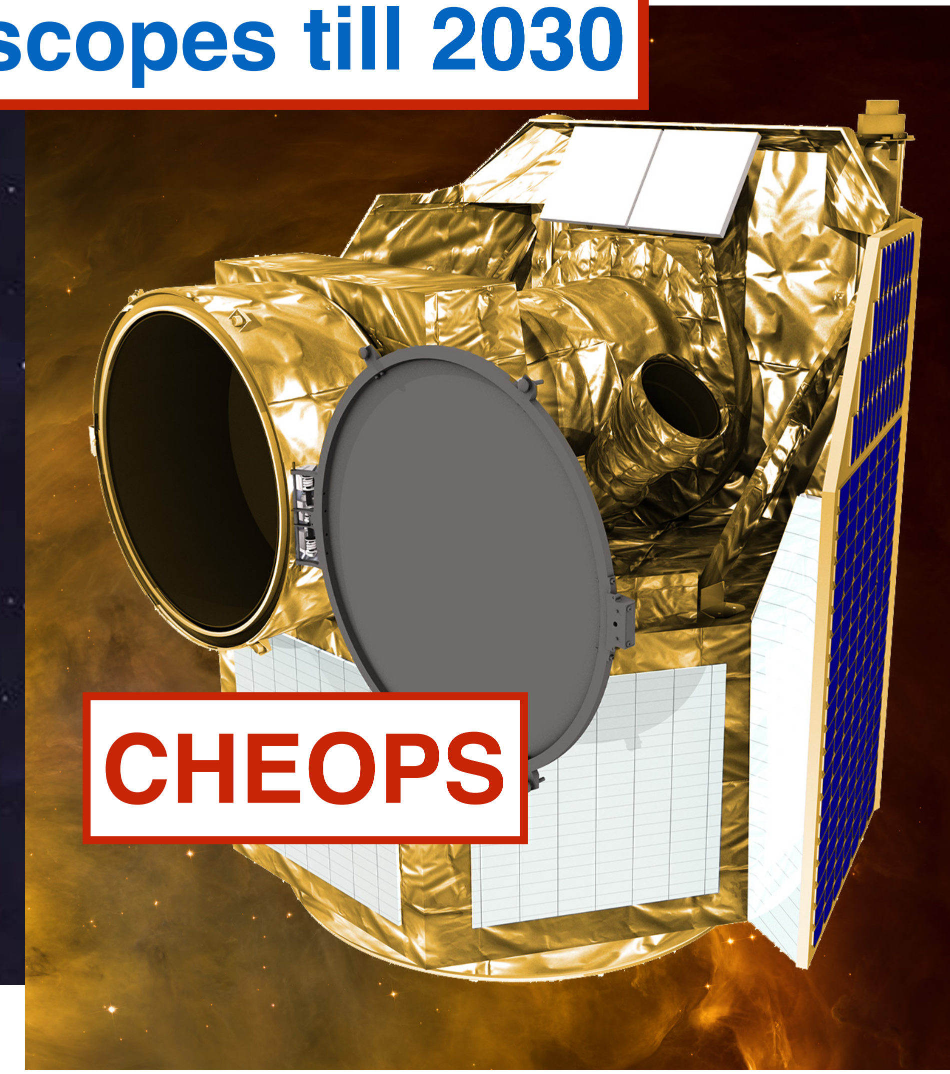
Kepler's Small Habitable Zone Planets

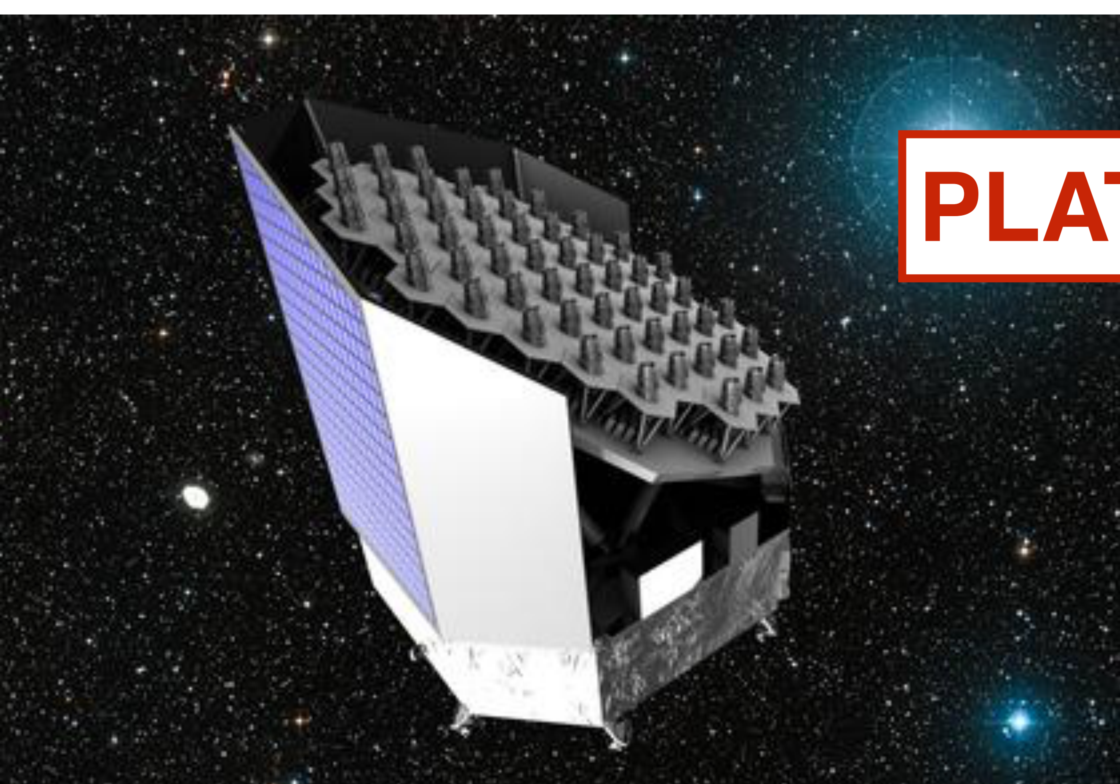
As of May 10, 2016

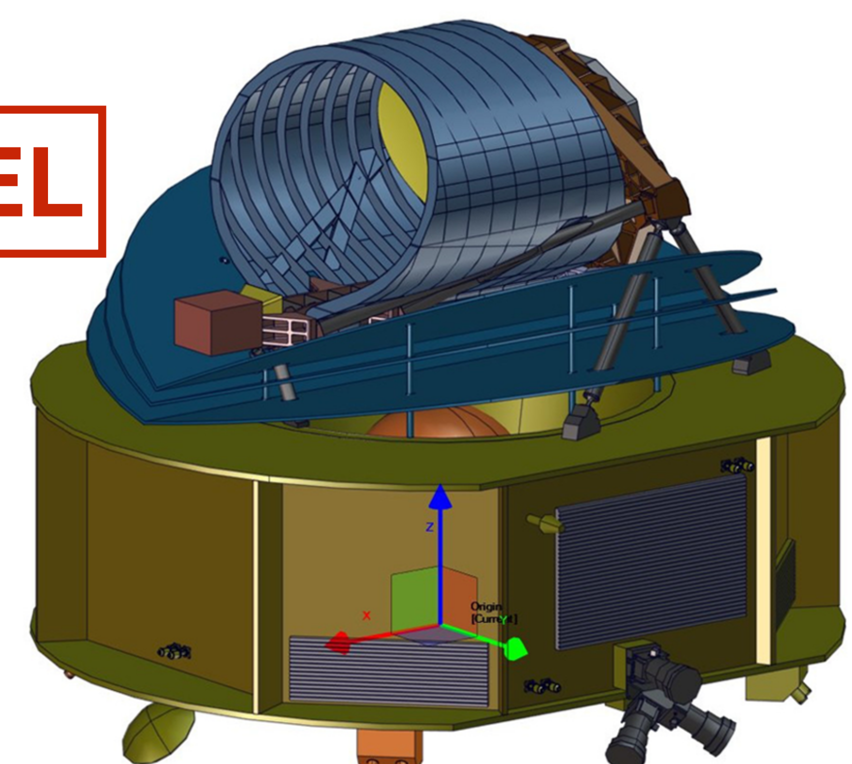


(NASA PR)

Dedicated exoplanet space telescopes till 2030

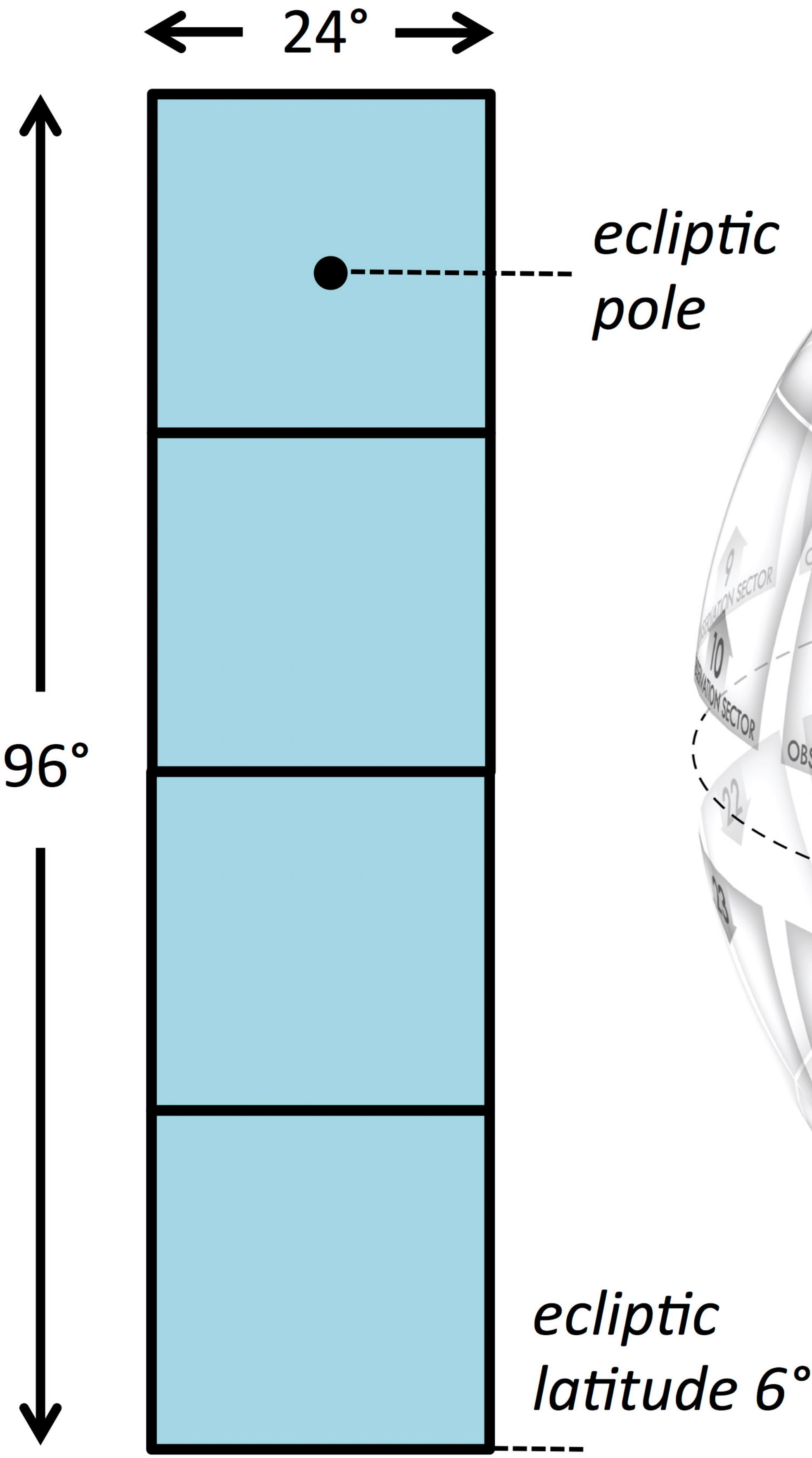




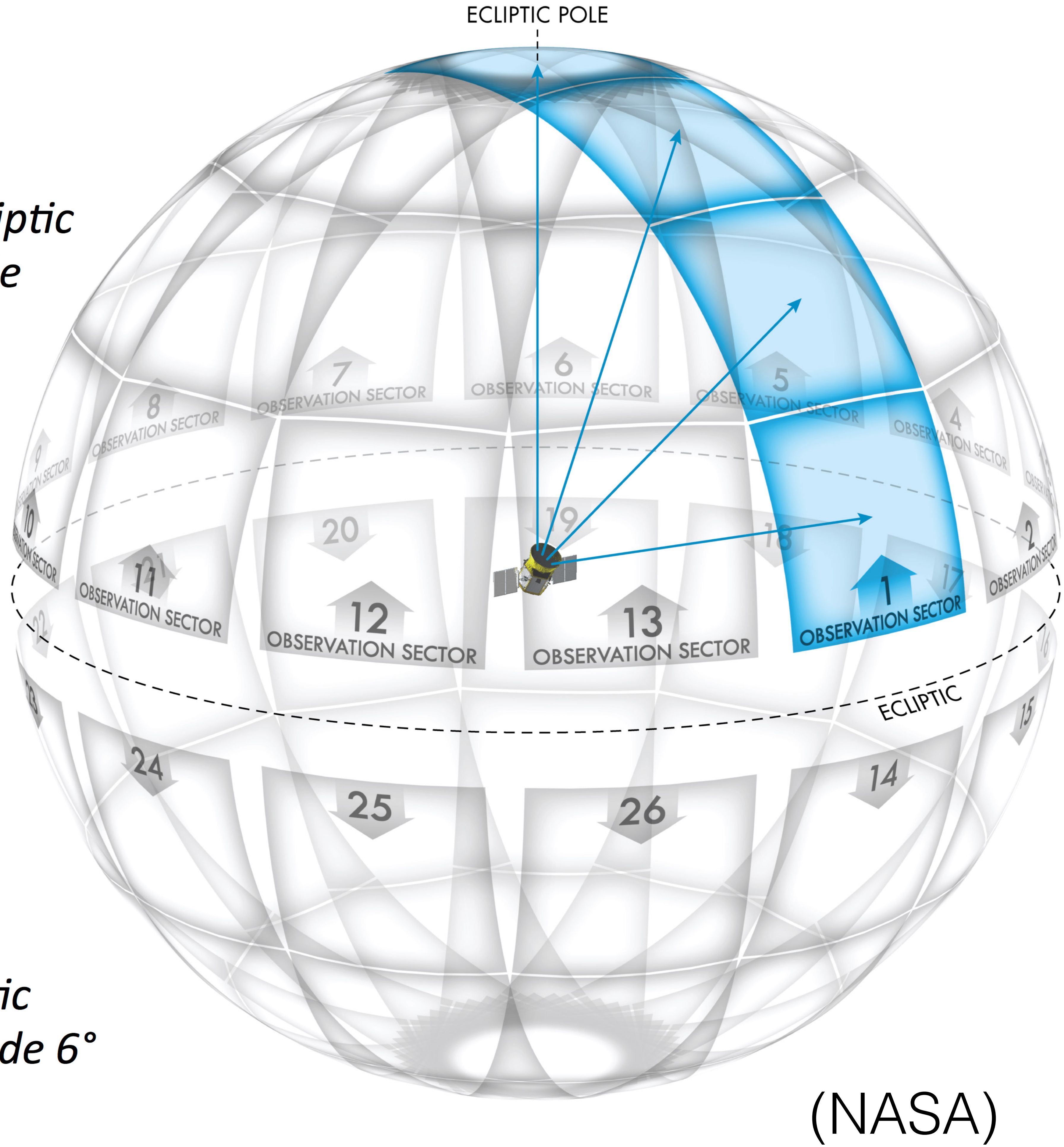


April 2018: TESS

- **T**ransiting **E**xoplanet **S**urvey **S**atellite
  - Bright stars (<~10 magn.), whole sky in two years
  - Four 10.5 cm cameras, 1/24th of the sky with CCDs (24 x 96 deg FoV)
  - (Short period) transiting exoplanets
  - Lot of additional science
  - NASA mission, PI George Ricker (MIT)

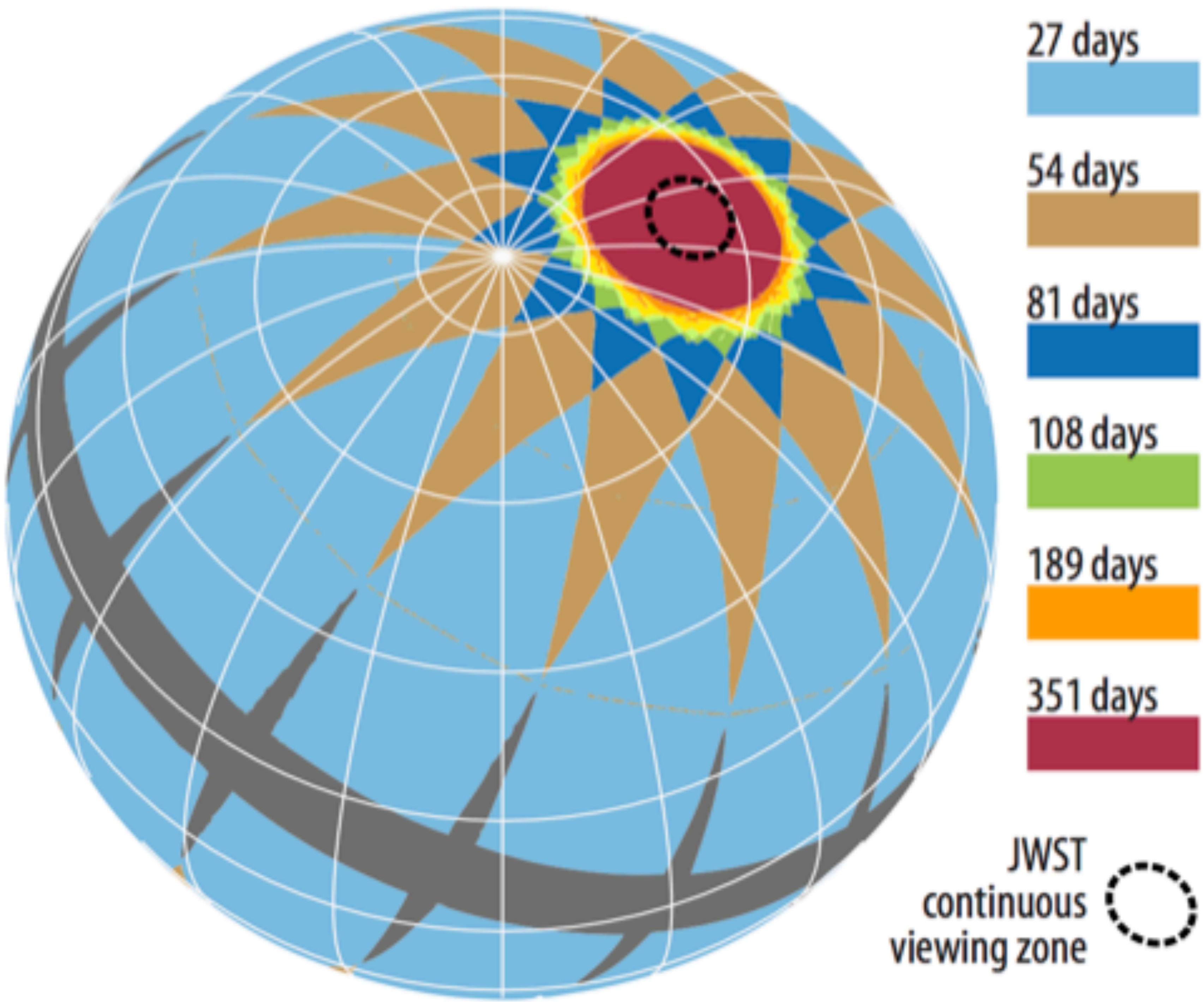


24°
96°
ecliptic pole
ecliptic latitude 6°

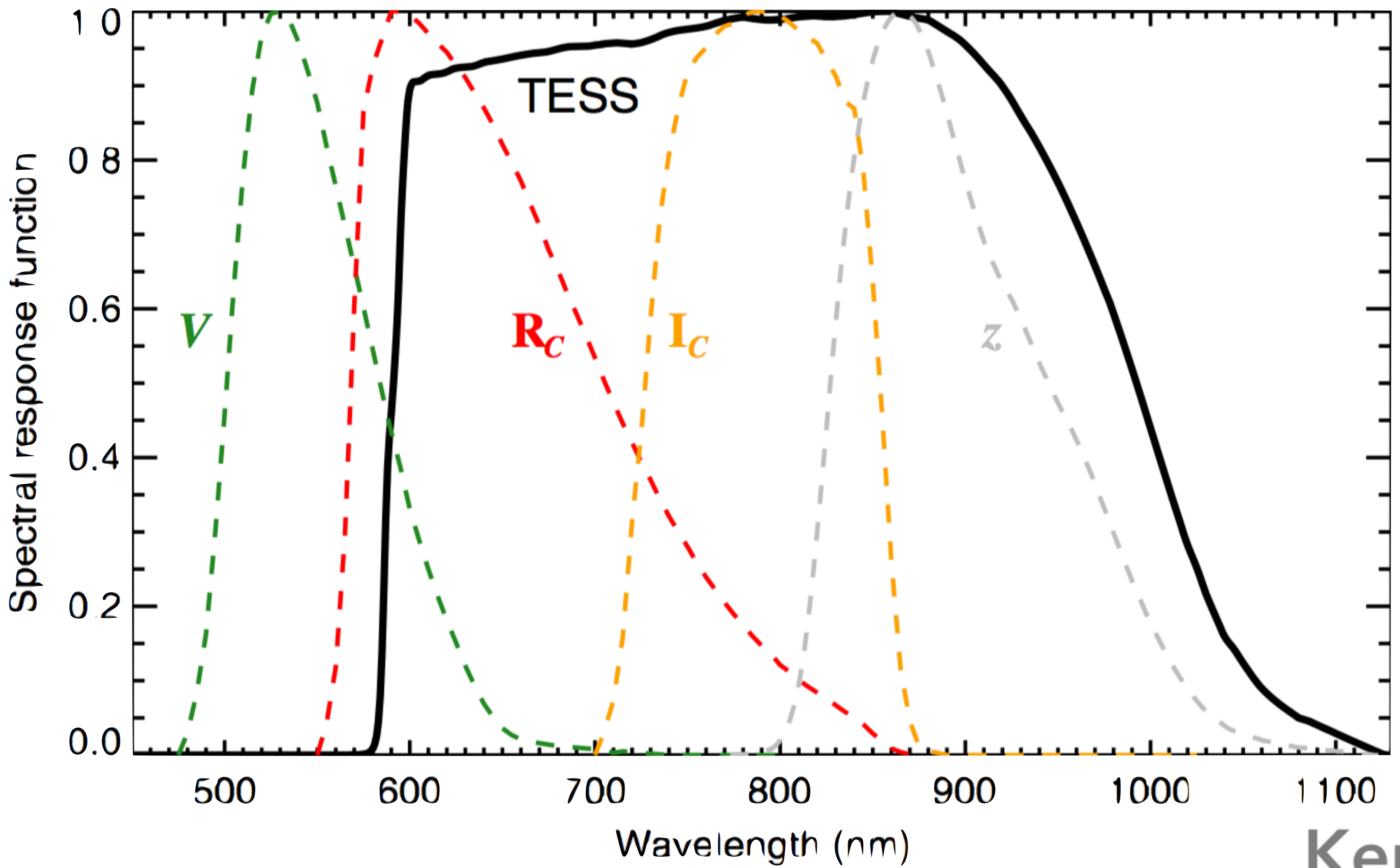


ECLIPTIC POLE
ECLIPTIC
1 OBSERVATION SECTOR
12 OBSERVATION SECTOR
13 OBSERVATION SECTOR
11 OBSERVATION SECTOR
8 OBSERVATION SECTOR
7 OBSERVATION SECTOR
6 OBSERVATION SECTOR
5 OBSERVATION SECTOR
4 OBSERVATION SECTOR
2 OBSERVATION SECTOR
20
19
18
24
25
26
14
15
(NASA)

Observability durations

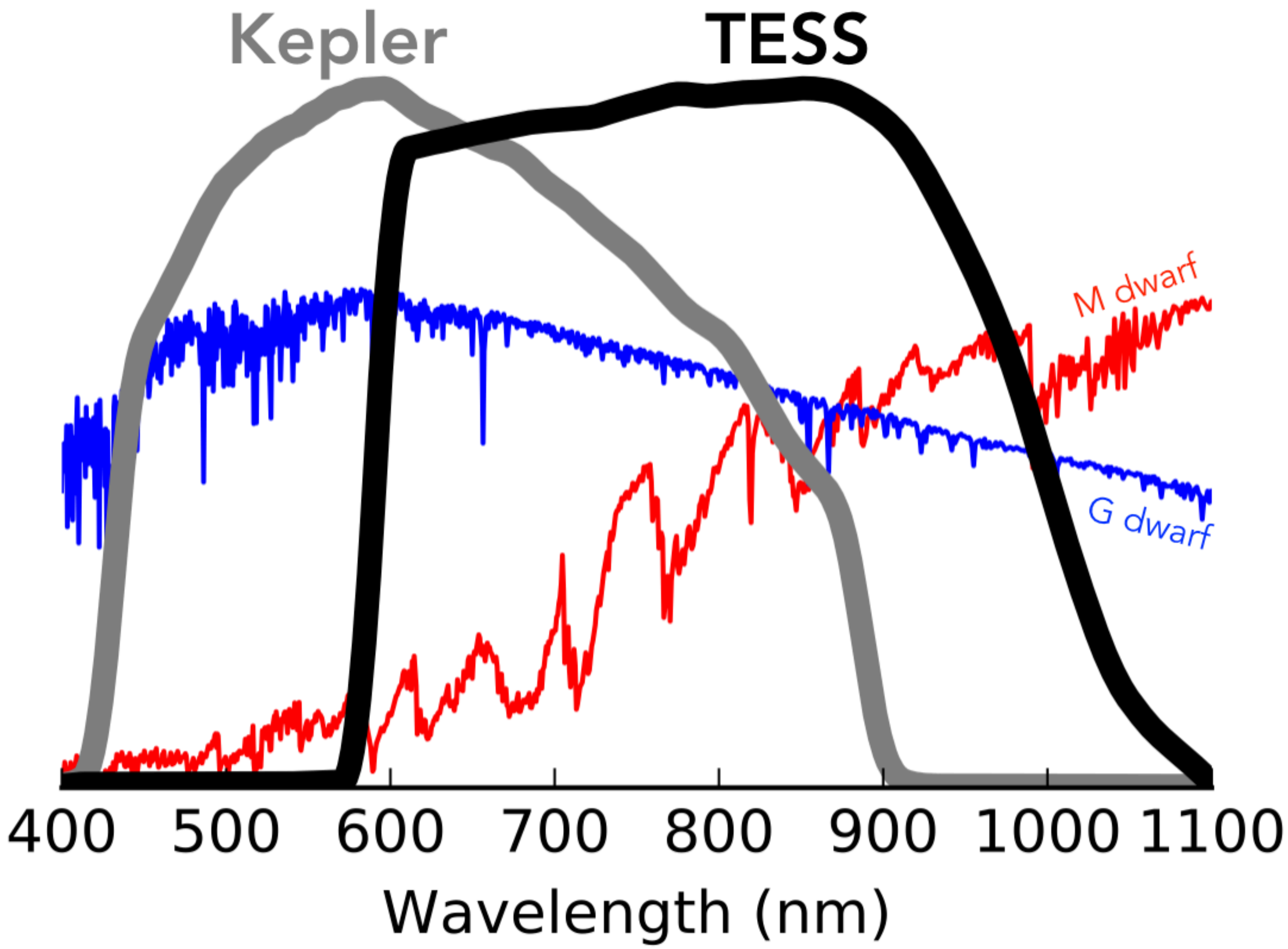


(NASA)



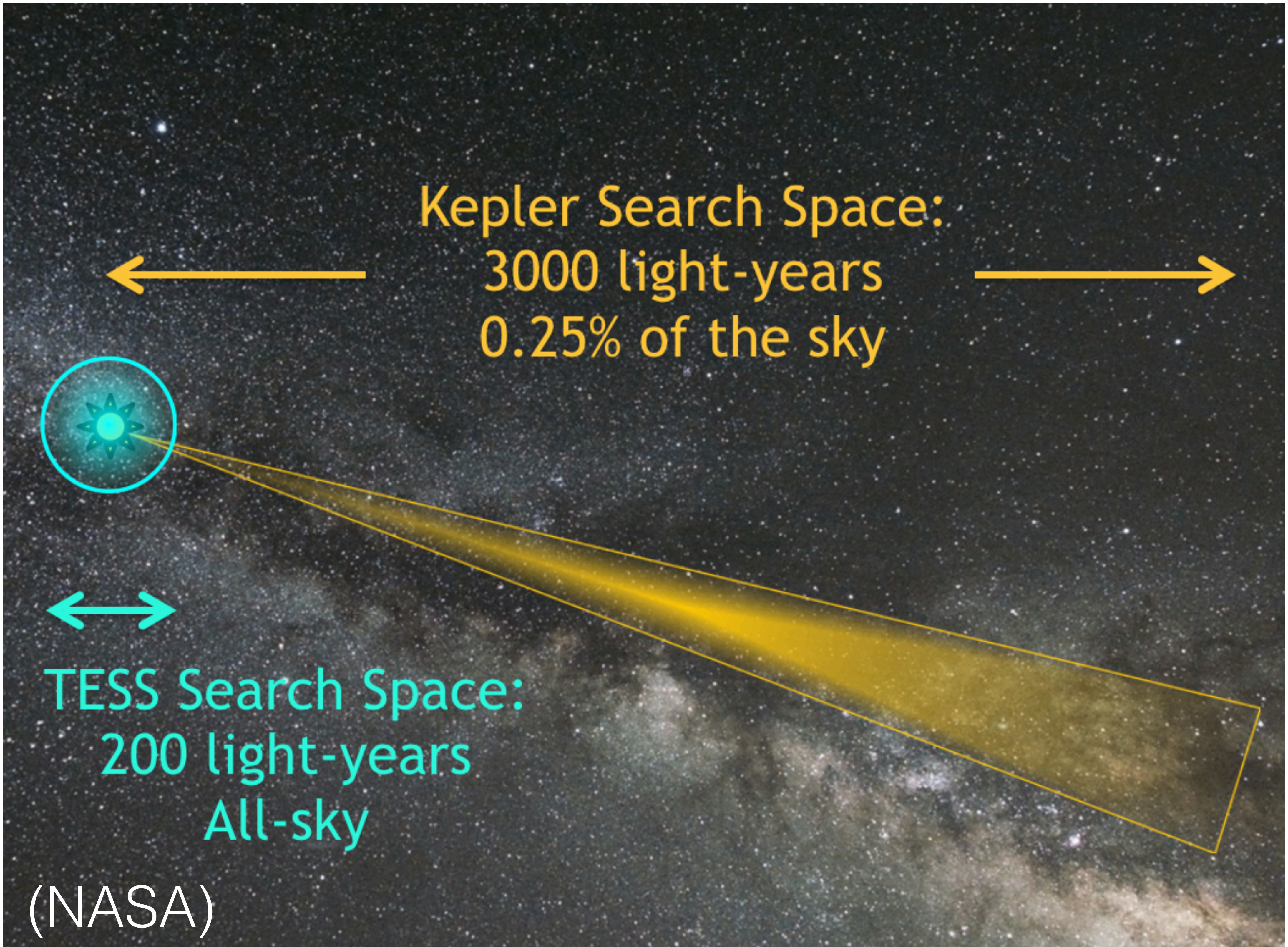
TESS spectral sensitivity

TESS vs. Kepler: more sensitive to red dwarfs



(NASA)

TESS vs. Kepler: the survey volumes



2018/19: CHEOPS

- **CH**aracterising **E**x**OP**lanet **S**atellite
  - Known exoplanet host stars (V<12 mag)
  - A single 33 cm RC telescope, unfiltered CCD
  - Follow-up measurements
  - Lot of additional science
  - ESA S1 mission, PI Willy Benz (Univ. Bern)

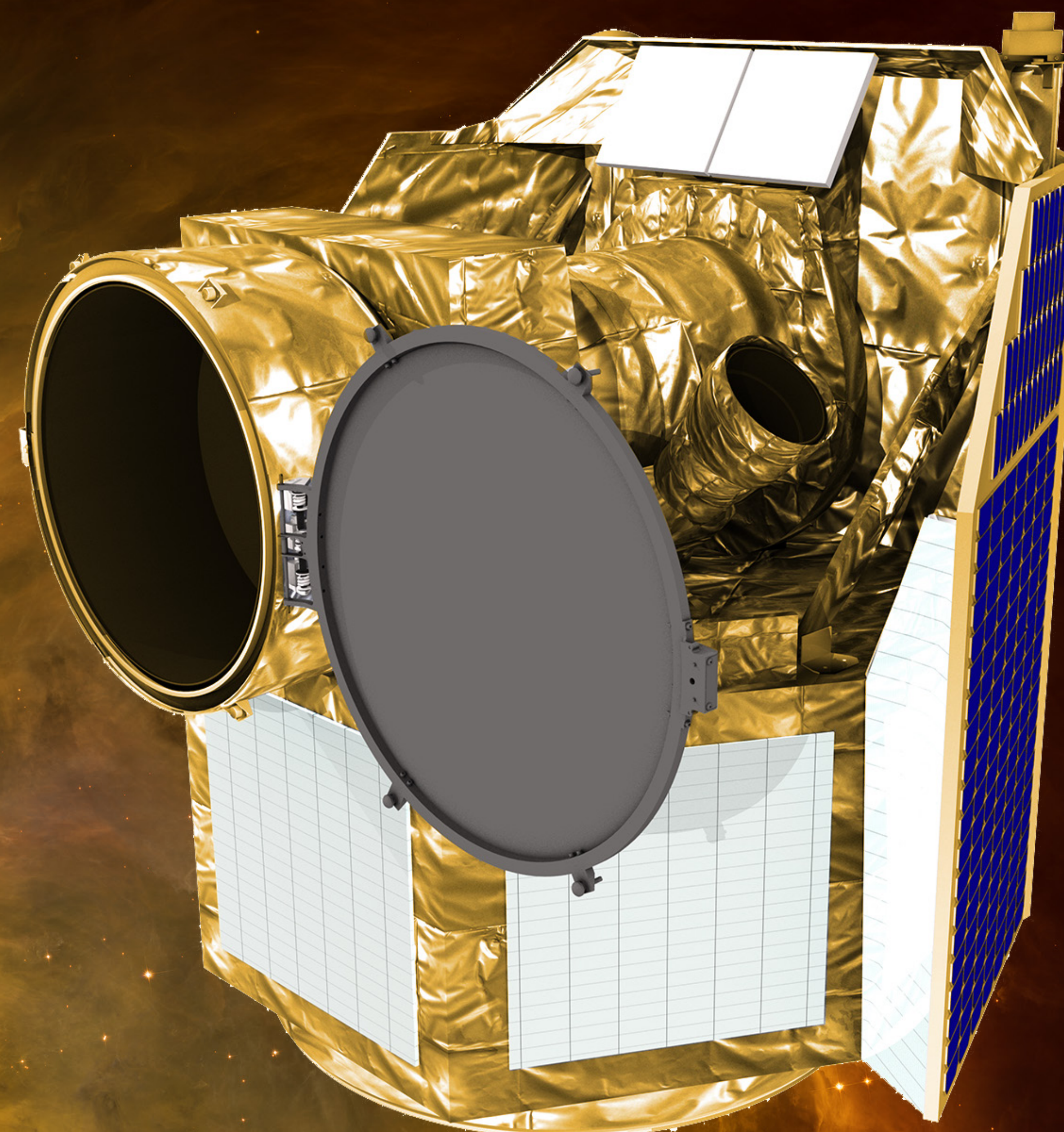
Partner institutions in eleven European countries contribute to the realisation of the space mission CHEOPS under co-leadership between Switzerland and the European Space Agency (ESA).

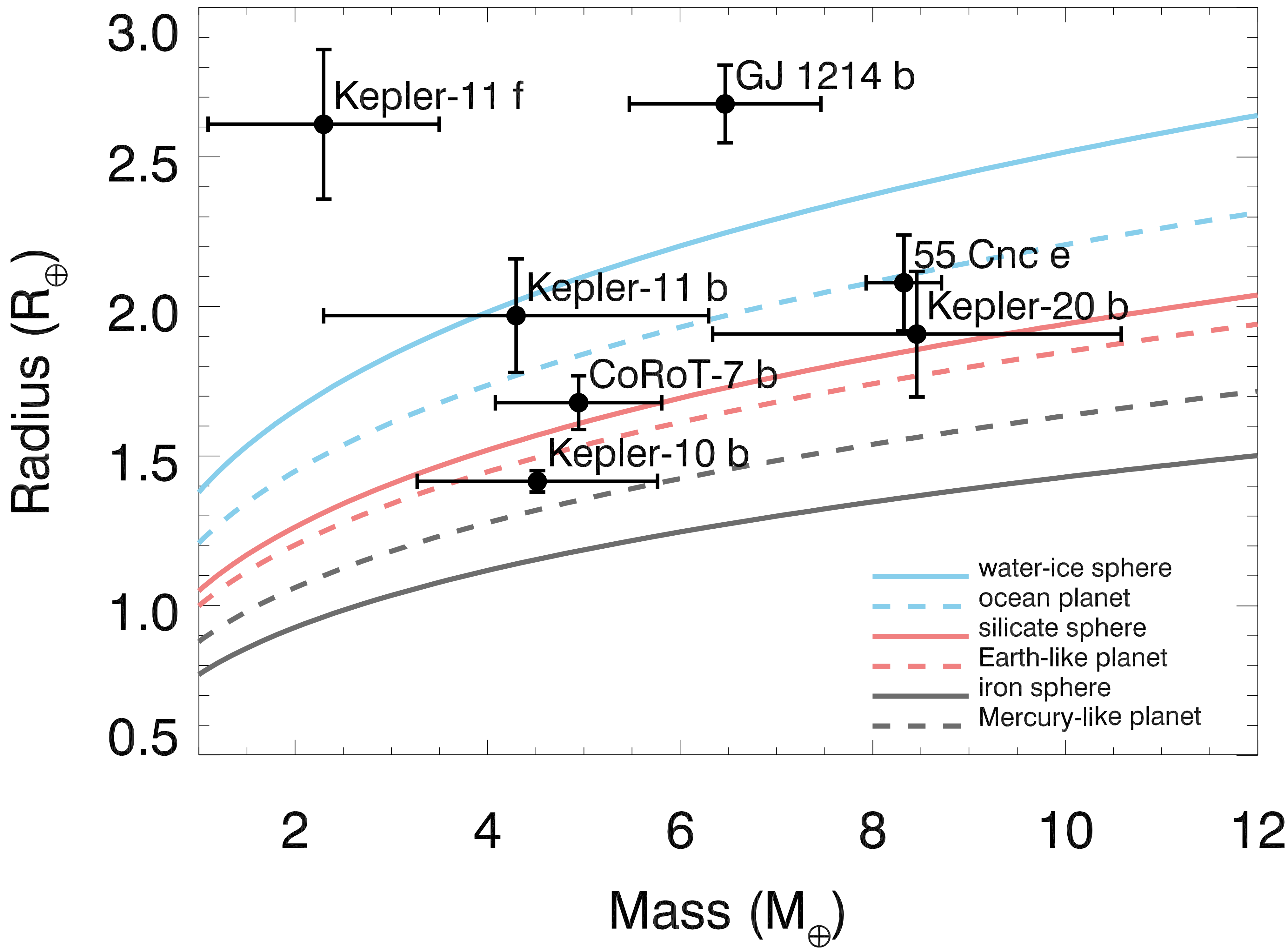
For Switzerland

Scientific institutions: CSH University of Bern, University of Geneva, Swiss Space Center, EPF Lausanne.

Industrial partners: Almatech/Connova, Pfeiffer Vakuum AG, P&P Software, RUAG Space, and other partners.

State Secretariat for Education, Research and Innovation SERI.



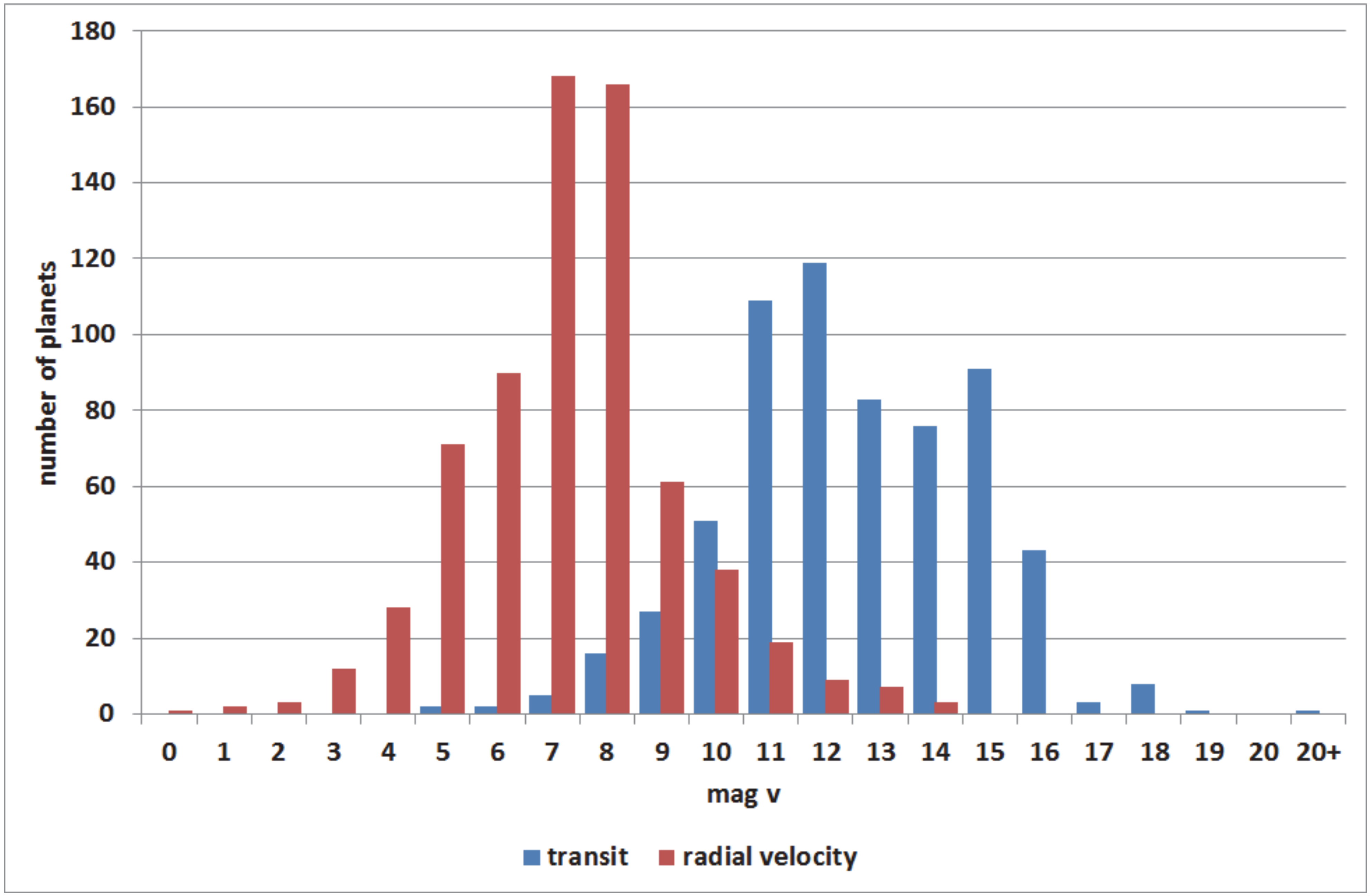


(CHEOPS Red Book)

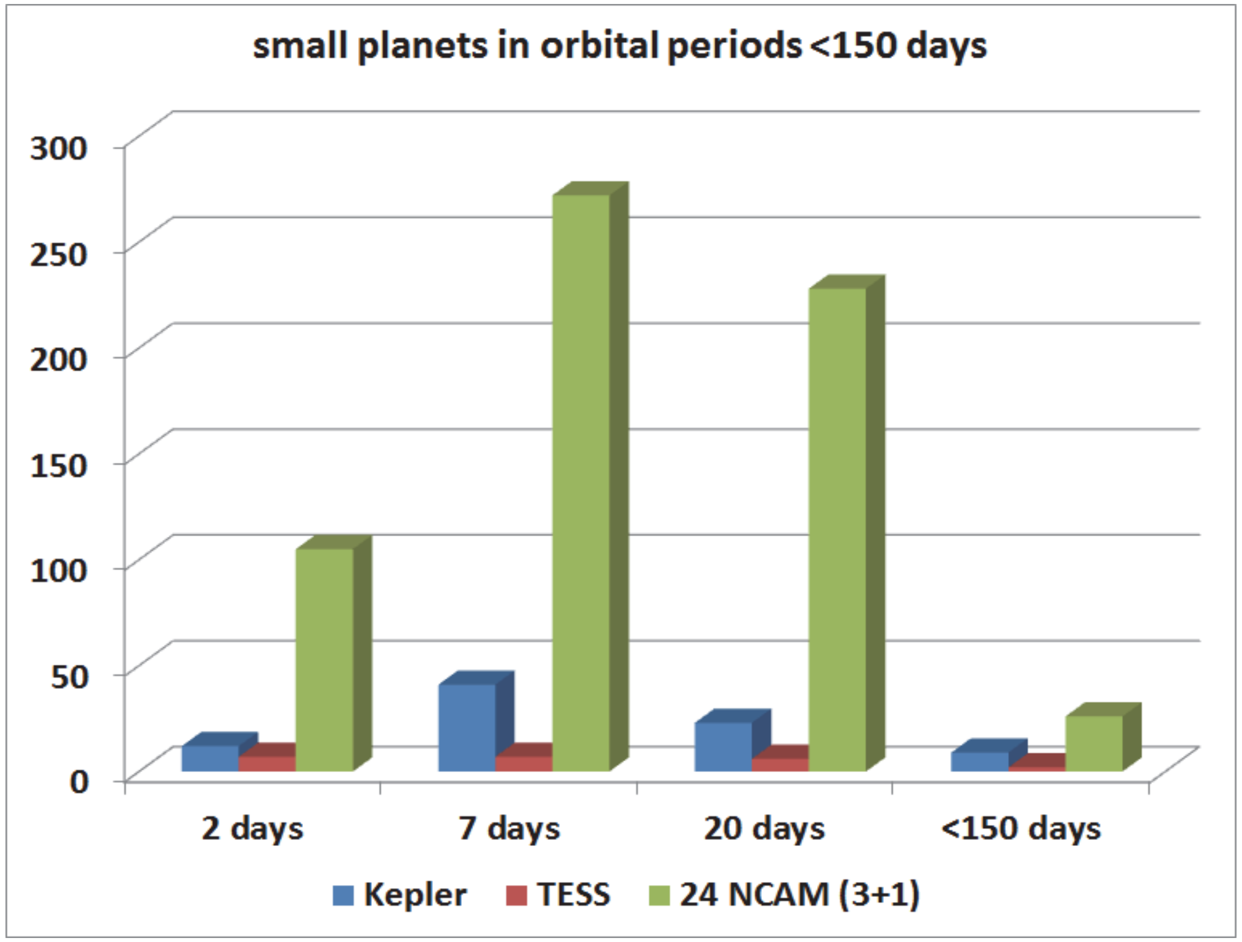
2026/27: PLATO

- **PLA**netary **T**ransits and **O**scillations of stars
  - Large samples of bright stars (~4-16 mag) for months to years
  - 24+2 12 cm cameras, FoV=2232 sq. deg.
  - Discovery of transiting exoplanets, asteroseismic characterisation of the central stars
  - ESA M3 mission, PI Heike Rauer (DLR, Berlin)

Doppler planets and transiting exoplanets



(PLATO Red Book)



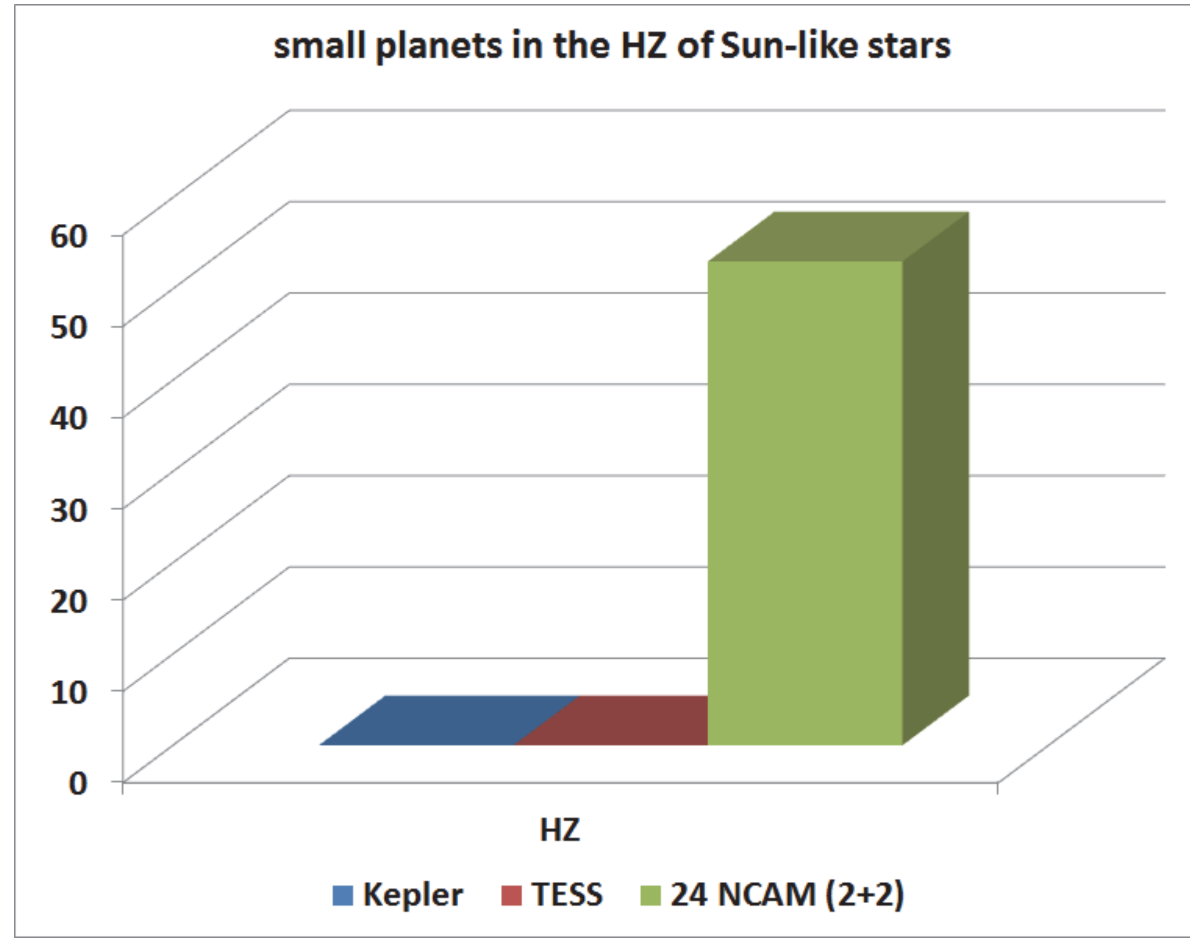


Figure 2.3: Expected yield of planets with highest characterisation accuracy (from P1 sample) in comparison to Kepler and TESS missions for two observing scenarios. Left, expected detection yield of small planets ($R < 2\,R_E$) around dwarf and sub-giant stars suitable for asteroseismology studies for Kepler (Lundkvist et al. 2016), TESS (Campante et al. 2016) and the PLATO core sample for an observing sequence of 3 years long pointing plus 1 year step-and-stare phase. We show orbital periods shorter than 150 days. Right, expected detection yield of small planets ($R < 2\,R_E$) in the habitable zone of solar-like stars for a scenario of 2 long pointings (baseline). For more details about how these values were derived, see Section 7.2.3.

(PLATO Red Book)

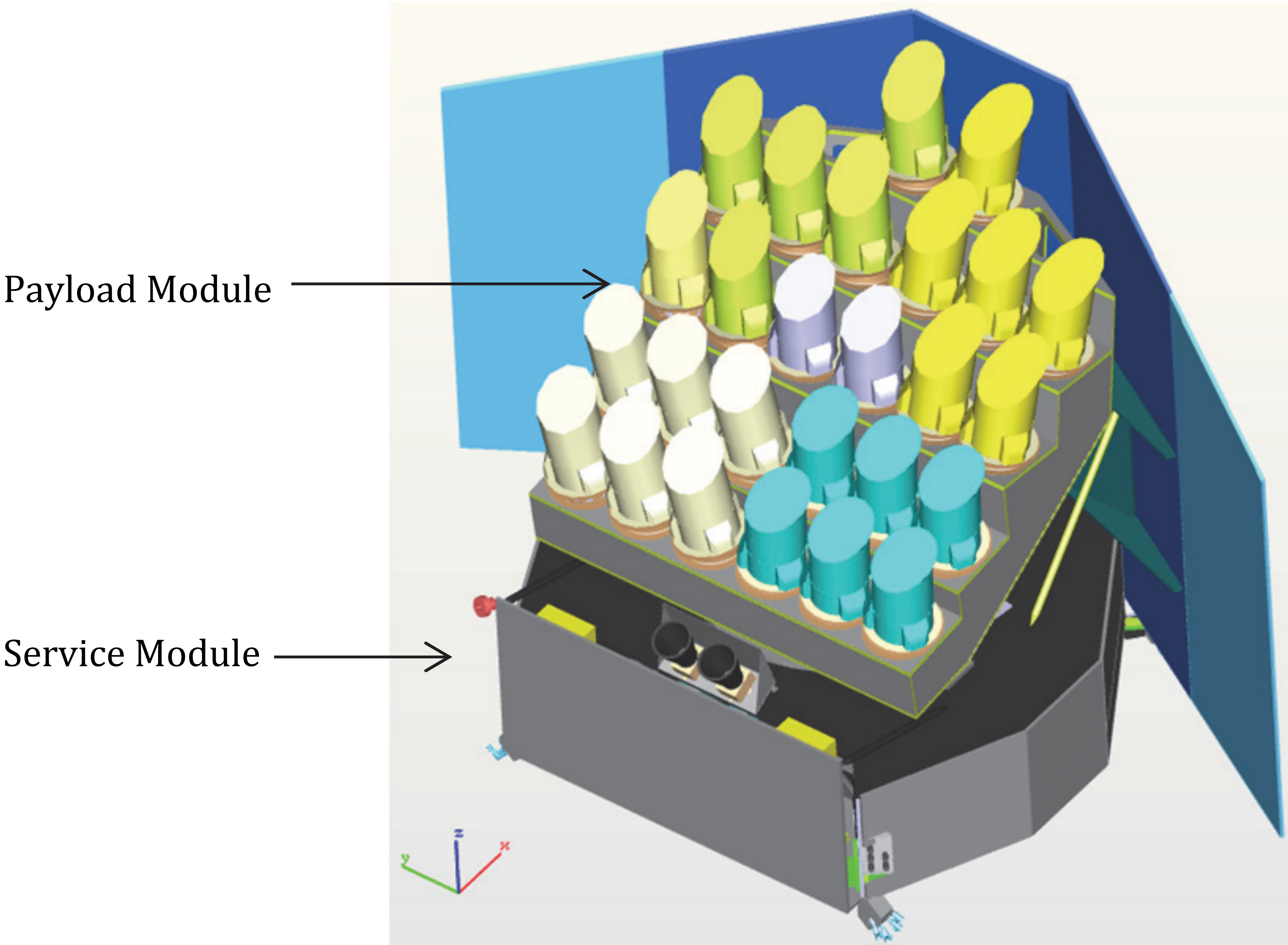
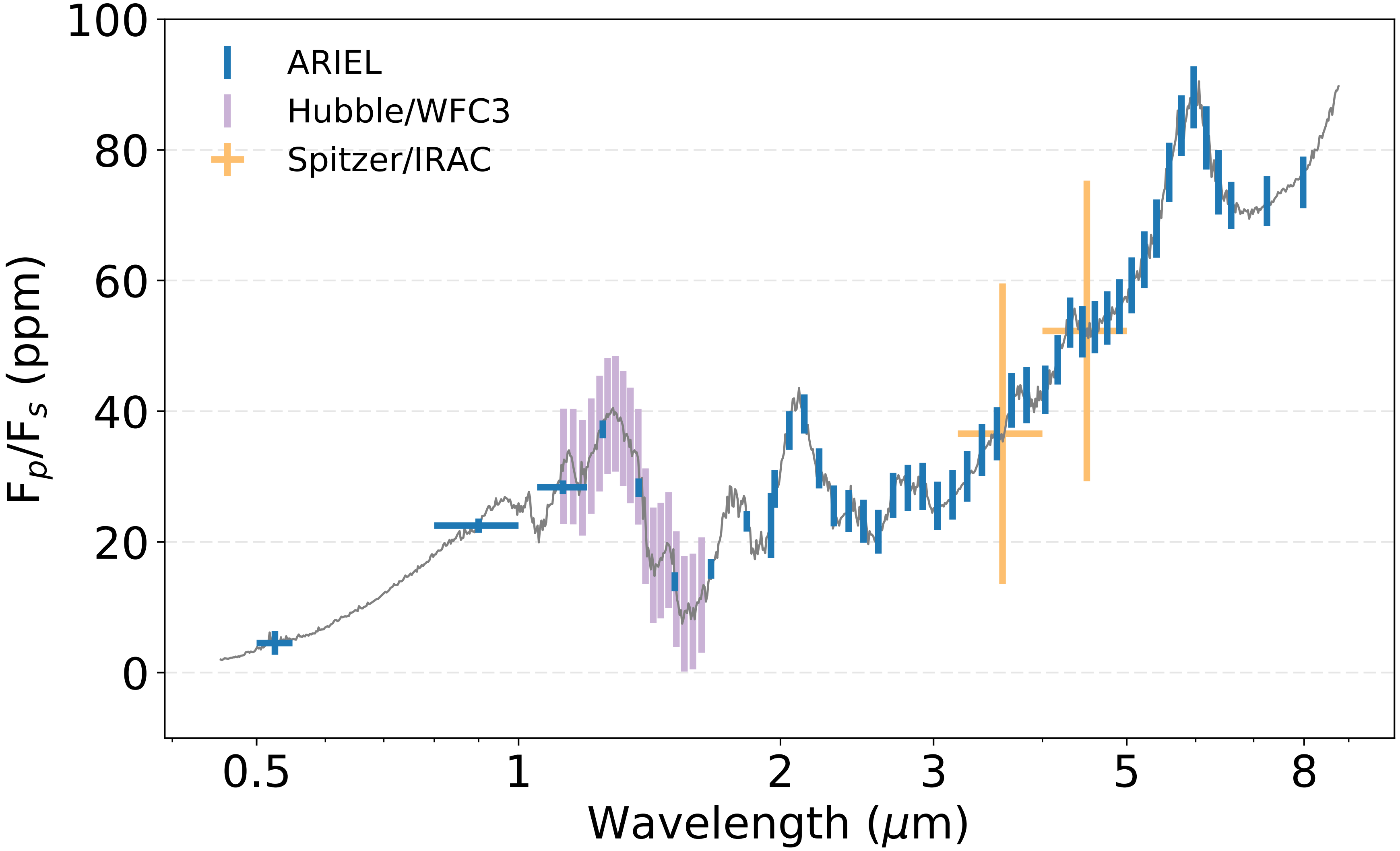


Figure 5.10: OHB spacecraft: separated PLM and SVM configuration.

2028: **ARIEL**

- **A**tmospheric **R**emote-sensing **I**nfrared **E**xoplanet **L**arge-survey
  - Infrared spectroscopy of ~1000 exoplanets
  - ~1 m IR telescope at L2
  - 0,5-8 micron spectra for atmospheric characterisation
  - ESA M4 mission, PI Giovanna Tinetti (UCL)



Expected output (with error bars) from the ARIEL processed data product compared with the input model assumption for a hot super-Earth similar to 55-Cnc-e around a G-type star with Kmag of 4. ARIEL performances using ***8 eclipses (~32 hours of observation)*** *are compared to currently available data for 55 Cnc e from Spitzer-IRAC (8 eclipses, Demory et al., 2016) and performances of Hubble-WFC3 extrapolated from transit observations of 55 Cnc e (Tsiaras et al., 2016).*

(ARIEL ASR)

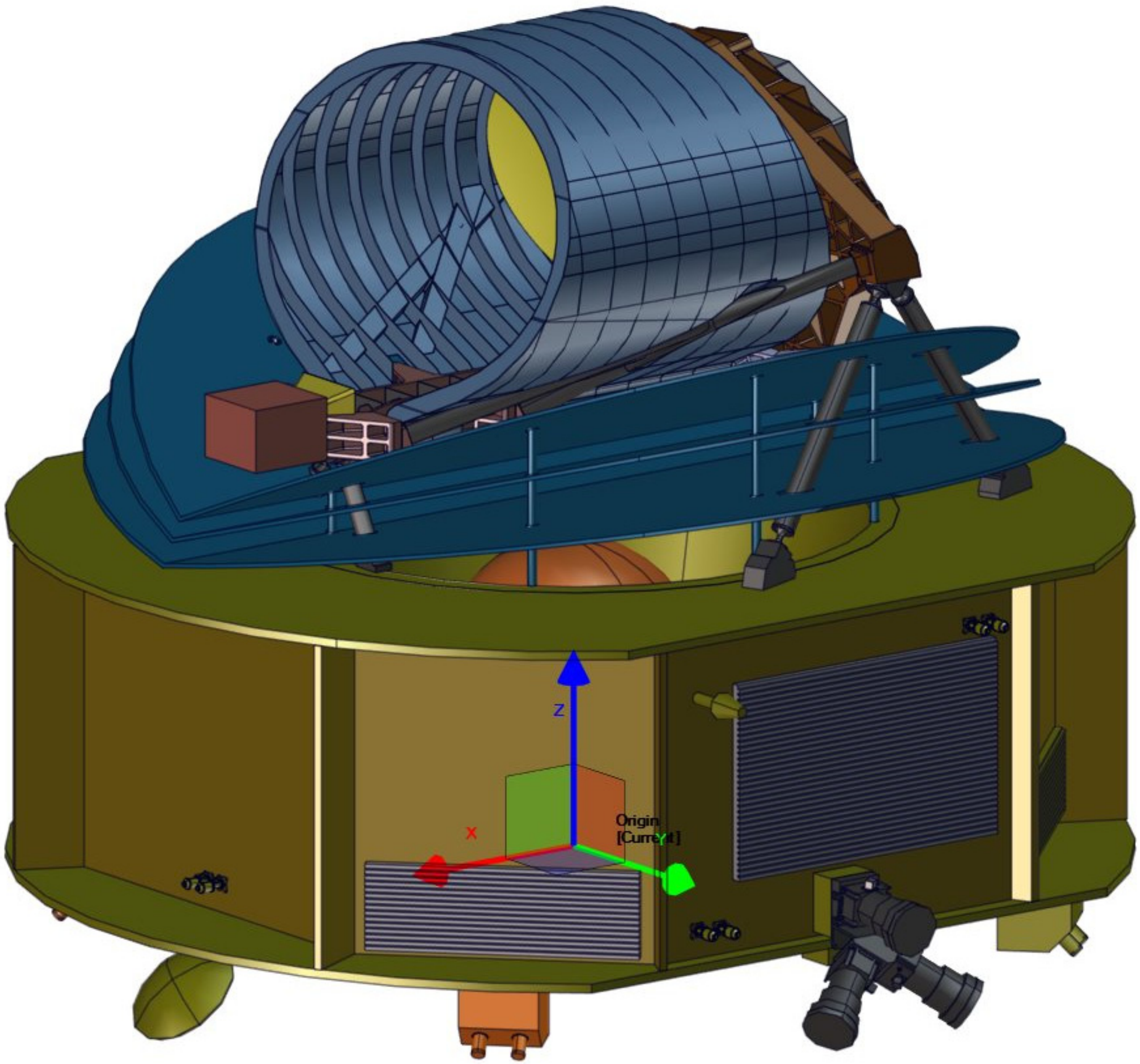


Figure 5-1:Illustration of the ARIEL S/C and its reference frame. The origin is at the geometrical centre of the separation plane between the LV adapter and the S/C (in the middle of the SVM bottom panel).The Z_{ARIEL} axis is coincident with the LV longitudinal axis (perpendicular to the separation plane or SVM bottom panel). The (X_{ARIEL}, Y_{ARIEL}) axes define the separation plane. X_{ARIEL} is parallel to the telescope pointing axis in this plane. Y_{ARIEL} completes the right-handed orthonormal triad. During nominal science operations, the Sun always remains underneath the SVM in the -Z_{ARIEL} hemisphere, to ensure the PLM is constantly obscured and can be passively cooled.

What can we expect?